KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES AND ENGINEERING
DEPARTMENT OF INFORMATION & COMPUTER SCIENCE

Ph.D. of Science in Computer Science

Student Guide

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Revision History

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Table of Content

1. Introduction

Computer science is an enormously vibrant field. From its inception over half a century ago, computer science has become the defining technology of our age. Computers are integral to modern culture and are the primary engine behind much of the world's economic growth. The field, moreover, continues to evolve at an astonishing pace. New technologies are introduced continually, and existing ones become obsolete in the space of a few years.

The Department of Information and Computer Science offers a PhD in Computer Science (Ph.D. CS) degree, which is in compliance with the international standards and recommendations.

2. ICS Department Vision and Mission

The vision of the ICS Department is to be a regional leader that is recognized worldwide in education, research and professional development in the areas of Computer Science and Software Engineering. The mission of the Department of Information and Computer Science is to:

- Provide high quality undergraduate and graduate educational programs in the fields of Computer Science and Software Engineering.
- Contribute significantly to the research and the discovery of new knowledge and methods in computing.
- Offer expertise, resources, and services to the community.
- Keep its faculty members current by providing opportunities for professional development.

3. Program Educational Objectives and Outcomes

3.1 Program Educational Objectives

In line of the vision and mission of the ICS Department, the objectives of the Ph.D. Program are to:

1. To provide high quality researchers and academicians needed in the country's development plans.
2. To improve KFUPM's research impact in computing-related areas
3. To provide specialized expertise through which advanced technologies and their applications can be enhanced, transferred, and utilized.

3.2 Program Learning Outcomes

Upon completion of the program, a graduate of the Ph.D. CS program will:

a. Be among the recognized experts in the area of research in Computer Science and be able to carry out research that advances scientific knowledge in their area of expertise.
b. Generalize from a collection of specific instances, discover patterns in the available information and draw conclusions and predict possible outcomes.
c. Be able to make an expert and novel use of software tools embodying the most recent theoretical advances in their area of research.
d. Analyze a complex research problem, consider a range of possible approaches to its solution, and determine the most promising approaches.
e. Be familiar with research methods, techniques, and problem-solving approaches from the field of research in which they are specializing.
f. Be aware of the publication process in peer-reviewed international outlets and be able to select the appropriate publication outlets for articles reporting on their research work.
g. Be able to engage in research and collaboration.

4. Program Requirements

The requirements of the proposed PhD program in Computer Science are the following:

4.1 Course Requirements

The student must choose one major area from the following list:
Area A: Algorithms and Applications (Applied Computing)
Area B: Systems and Languages
Area C: Security and Net-centric Computing
Area D: Software Engineering

- **Major Area:** 3 courses to be taken from the selected major Area:
  - At least 1 of the 3 courses must be 600-level
- **Breadth Coverage:** 3 courses to be taken from at least two areas other than the major area.
- **CS Elective:** 1 course to be taken from any of the four areas.
- **Free Electives:** 3 elective courses to be taken from the ICS department (other programs) or from any other department (e.g. COE, Math, EE, etc.).
  - At least two of these must be taken from outside the four CS areas.
- **Seminar:** 1 seminar course:
  - ICS699: Seminar

4.2 Other Requirements

- Comprehensive Exam
- Dissertation Proposal:
  - ICS 711: PhD Pre-Dissertation
- Dissertation:
  - ICS 712: PhD Dissertation

4.3 Program Requirements Description

Students enrolled in this program are required to complete 30 credit hours of courses (excluding the dissertation) for graduate credits. These courses should be according to each student's degree plan that has been approved by the department's Graduate Committee, the Department Chairman, and the Dean of Graduate Studies.

The PhD degree in Computer Science will be awarded to candidates who fulfill the requirements specified by the Deanship of Graduate Studies, as well as the following additional requirements imposed by the Information and Computer Science Department:

1. Satisfaction of provisional status requirements; if any,
2. Satisfactory completion of the coursework requirements (30 credit hours),
3. Passing the written comprehensive examinations by the end of the 4^{th} semester after joining the program (A graduate student is allowed to take these examinations only twice),
4. Passing the oral proposal public defense (ICS 711) in conjunction with the Seminar Course (ICS 699) by the end of the 5th semester after joining the program, and
5. Successful completion and defense of an original dissertation research work (ICS 712).

A full-time PhD student is expected to spend about two years completing his required course work. The dissertation work is also expected to require about two years. The maximum

period permitted to complete the PhD is five years for a full-time PhD student and seven years for a part-time student. A student must spend a minimum of one year in residence doing his PhD dissertation work.

The Program is designed in a way that ensures breadth coverage up to the level of the awarded degree as well as depth coverage to emphasize the area of specialization for the awardee. The program provides breadth coverage of Computer Science topics through the arrangement of courses into four subject areas. Each student is expected to select one subject area as his major (dissertation) area. The subject areas are:

- Area A: Algorithms and Applications (Applied Computing)
- Area B: Systems and Languages
- Area C: Security and Net-centric Computing
- Area D: Software Engineering

The Comprehensive Exam must cover three subject areas according to the student's preference. The completion of at least 30 credit hours of course work beyond the M.S. course work and beyond remedial courses is required for all PhD students. Each student must select one of the subject areas as his major area. The student may take for credit any of the CS 500-level (or higher) courses listed under the four subject areas, provided that such courses have not been taken for credit by the student for a previous degree at KFUPM. To ensure depth of knowledge, a minimum of three courses must be taken from the student's selected major area with, at least, one of these courses being a 600-level course. To provide breadth of knowledge, the student must take courses from at least two CS PhD areas other than his major. In addition, the student is required to take three graduate elective courses two of which must be taken from outside the lists under the subject areas.

The required 600-level course cannot be replaced by the 700-level directed research or other self-study 600-level courses.

Each student is also required to present a seminar that describes recent research findings in Computer Science as well as to attend the technical seminar series organized by the ICS Department. This requirement is fulfilled by the zero-credit hour seminar course ICS 699 (1-0-0).

Three credit hours are assigned to the development of the PhD Dissertation Proposal (ICS 711), this is to enable the student to prepare and publicly defend the proposed discretion research. Nine credit hours are assigned to the PhD Dissertation effort (ICS 712), which is expected to involve original scholarly research applied to a carefully defined problem. The research problem may belong to any of the Computer Science subject areas.

4.4 List of courses per Area

Area A: Algorithms and Applications	Area B: Systems and Languages
ICS 553: Algorithms and Complexity ICS 546: Multimedia Information Management ICS 545: Arabic Computing ICS 582: Natural Language Processing ICS 583: Pattern Recognition ICS 547: Digital Image Processing ICS 557: Machine Learning ICS 558: Introduction to Bioinformatics and Biomedicine	ICS 531: Advanced Operating Systems ICS 532: Performance Analysis and Evaluation ICS 533: Modeling and Simulation of Computing Systems ICS 535: Theory and Design of Programming Languages ICS 541: Database Design and Implementation
ICS 611: Combinatorial, Approximation and Probabilistic Algorithms ICS 614: Advanced Pattern Recognition ICS 615: Advanced Computer Vision	ICS 630: Distributed Systems ICS 633: Semantics of Programming Languages

Area C: Security and Net-centric Computing	Area D: Software Engineering
ICS 555: Cryptography and Data Security ICS 570: Computer Communication Network ICS 571: Client Server Programming ICS 572: Distributed Computing ICS 573: High-Performance Computing ICS 575: Application Development for Internet Based Services ICS 576: Concurrent and Parallel Processing COE 541: Local and Metropolitan Area Networks COE 542: High-Speed Networks COE 543: Mobile Computing and Wireless Networks CNW 550: Computer Network Design CNW 554: Modeling and Analysis of Computer Networks CNW 555: Protocol Engineering SEC 511: Principles of Information Assurance and Security SEC 521: Network Security SEC 524: Computer and Network Forensics SEC 528: Security in Wireless Networks SEC 534: Database Security SEC 536: Web Application Security SEC 538: Trusted Computing SEC 544: Biometric Systems SEC 546: Embedded Systems Security SEC 548: Watermarking and Steganography SEC 595: Special Topics in Information Assurance and Security SEC 531: Secure Software	SWE 515: Software Requirements Engineering SWE 516: Software Design SWE 526: Software Testing and Quality Assurance SWE 531: Secure Software SWE 532: Web Applications Security SWE 536: Software Architecture SWE 539: Software Metrics SWE 566: Software Agents SWE 585: Empirical Software Engineering SWE 587: Software Project Management SWE 595: Special Topics in Software Engineering
ICS 654: Advanced Topics in Computer Networking SEC 611: Cryptographic Computations SEC 621: Advanced Network Security SEC 631: Security in Operating Systems and Cloud Computing	SWE 634: Software Reuse SWE 638: Software Maintenance & Re-Engineering SWE 670: Formal Methods and Models in Software Engineering SWE 671: Global Software Engineering

4.5 Degree Plan

	First Semester		Second Semester		
Course	Description	CR	Course	Description	CR
ICS xxx	Student's Major Area	3	ICS xxx	Student's Major Area	3
ICS xxx	Student's Breadth	3	ICS xxx	Student's Breadth	3
ICS xxx	Student's Breadth	3	ICS xxx	CS Elective	3
	Total	9		Total	9
	Third Semester		Fourth Semester		
Course	Description	CR	Course	Description	CR
ICS xxx	Student's Major Area	3	XXX xxx	Free Elective III	3
XXX xxx	Free Elective I	3	ICS699	Seminar	0
XXX xxx	Free Elective II	3	ICS 711	PhD Dissertation Proposal	3
	Total	9		Total	6
	Fifth Semester		Sixth Semester		
Course	Description	CR	Course	Description	CR
ICS 712	PhD Dissertation	9	ICS 712	Ph.D. Dissertation	
	Total	9			

Notes:

- All courses must be graduate level courses.
- "ICS 500 Research Methods and Experiment Design in Computing" or equivalent is a pre-requisite for admission.
- One of the student major area course must be a 600-level course.
- The three XXX xxx courses are the graduate general elective courses

5. Admission Requirements

The admission process starts with an application to the College of Graduate Studies. A student can apply for one of the following statuses:

1. Research Assistant (only foreign nationals),
2. Graduate Assistant (only Saudi nationals),
3. Full time graduate student,
4. Part time graduate student.

The applicant must fill all related forms which can be obtained from the Deanship of Graduate Studies office or website. The applicant must also submit the following:

- A letter of intent
- Graduation certificates
- Transcripts
- At least three reference letters
- Official TOEFL scores report
- General GRE scores report

An PhD applicant must have an M.Sc. degree in computer science from an institution whose undergraduate and graduate programs are at least comparable to those of KFUPM in both content and quality. All applicants must have a cumulative GPA of at least 3.0 out of 4. In order for an applicant to be admitted to the Ph.D. CS program.

An application must have a strong background in the following core areas of computer science:

- Data Structures
- Computer Architecture
- Algorithms
- Programming Languages
- Database Systems
- Computer Networks
- Operating Systems

Similar course to “ICS 500: Research Methods and Experiment Design in Computing”, is also a pre-requisite for admission. This requirement can be waived if adequate publication record is shown by the student at application time. Unsatisfactory background in any of these areas is considered a deficiency. Conditional admission may be granted to otherwise qualified students with some core background deficiencies. Students with deficiencies must take the corresponding appropriate course(s) at KFUPM. Any deficiency must be completed with a grade of B or better before a change of status to regular is realized.

6. Courses Descriptions

6.1 Area A: Algorithms and Applications

ICS 553: Algorithms and Complexity **3-0-3**
Computational complexity: P-space and EXP classes, Reduction, NP-complete problems, Cook's theorem, Randomized algorithms, Approximation algorithms, Branch-and-Bound, Amortized analysis; Max flow, Bipartite matching; Geometric algorithms: Convex hull, Closest pairs; Computability: Turing machines, Church-Turing thesis, Rice's theorem, Undecidability.
Prerequisites: ICS 353 or equivalent

ICS 546: Multimedia Information Management **3-0-3**
Multimedia data representation and management in the context of contentbased retrieval, audio, image and video data representation, Information retrieval from text. Content based retrieval of audio, image and video data, Similarity measures. Query formulation and evaluation, Multi-dimensional indexing algorithms and data structures. Multimedia compression. Multimedia data mining.
Prerequisites: Consent of Instructor

ICS 547 Digital Image Processing **3-0-3**
Continuous Image. Mathematical Characterization. Psychovisual Properties. Photometry and Colorimetry. Superposition and Convolution. Image Transforms. Linear Processing Techniques. Image Enhancement. Morphological Image Processing. Edge Detection. Image Feature Extraction. Image Segmentation. Shape Analysis.
Prerequisites: Consent of Instructor

ICS 557 Advanced Machine Learning **3-0-3**
Linear and logistic regression. Regularization. Generalized linear models. Learning theory. Support vector machines. Kernel methods. Principal component analysis. Independent component analysis. Hidden Markov models. Random forests. Design of learning systems. Recommender systems. Online Learning. Ensemble learning models. Bootstrapping techniques.
Prerequisites: ICS 485 or Consent of the Instructor

ICS 558 Introduction to Bioinformatics and Biomedicine **3-0-3**
This course offers an introduction to bioinformatics with an emphasis on biomedical aspects. Topics include bioinformatics databases, sequence alignments, protein domains, protein-protein interaction, gene expression, gene ontology, pathways, disease state analysis, and computational methods in biomedicine.
Prerequisites: Consent of the Instructor

ICS 611 Combinatorial, Approximation and Probabilistic Algorithms **3-0-3**
Representation and generation of combinatorial objects, Graph algorithms, Greedy method and the theory of matroids. Graph matching and applications. Network flows and applications. Approximation algorithms to combinatorial problems like scheduling, bin-packing, knapsack, vertex cover, TSP, clique partitioning, graph compression, Steiner problem on networks. Randomized algorithms: Monte-Carlo, Las-Vegas, algorithms, occupancy problems, randomized sorting and pattern matching, Markov chains and random walks.
Prerequisites: ICS 553 or Consent of the Instructor

ICS 614 Advanced Pattern Recognition **3-0-3**
The course covers advanced topics in pattern recognition and machine learning. Recent conference and journal papers will be discussed in depth. Tentative topics: Classification and discriminant analysis, feature generation using transformations. Feature selection, data transformation and dimensionality reduction, Classifier evaluation, Kernel methods, error rate estimation techniques and performance evaluation. Actual topics covered will depend on time available and students' interests.
Prerequisites: ICS 583 or equivalent

ICS 615 Advanced Computer Vision **3-0-3**
This course intends to provide an in-depth overview of the current state-ofthe-art of computer vision by covering a set of advanced topics that are actively investigated. Recent conference and journal papers will be discussed in depth. Tentative topics: Low level vision: Image Segmentation, Stereo, Optical flow, de-noising and texture analysis; Higher level vision: Object Detection and Recognition/Pose Estimation; geometrical and 3D vision, stereo, 3D scene reconstruction, motion analysis, visual tracking, object recognition and human motion analysis, capturing and recognition. Actual topics covered will depend on time available and students' interests.
Prerequisites: ICS 547 or Consent of the Instructor

6.2 Area B: Systems and Languages

ICS 531 Advanced Operating Systems **3-0-3**
Advanced concepts in operating systems design; multiprocessing model, interprocess communication; synchronization mechanisms; resource management and sharing; scheduling in multiprocessor system; Process migration; Operating system-level virtualization; Special-purpose operating systems: Real-time, Distributed and network operating systems; Distributed deadlock handelling; Distributed file system; Distributed shared memory; Replication & consistency; In addition, students will be exposed to recent developments in operating systems through research projects and papers.
Prerequisites: Consent of the Instructor

ICS 535 Theory and Design of Programming Languages **3-0-3**
Fundamentals of type systems, type inference, control structures, and storage management. Formal syntax specification. Semantic specification models: axiomatic, operational and denotational. Project(s) to design a programming language.
Prerequisites: ICS 410 or Equivalent

ICS 630 Distributed Systems **3-0-3**
Taxonomy of distributed systems: Client-server, cluster systems, Grid systems, P2P systems, cloud systems, volunteer-based systems. Distributed systems service models. Modeling, performance, scalability, elasticity and trust/reputation issues in distributed systems. Project(s).
Prerequisites: ICS 531 or Consent of Instructor.

ICS 633 Semantics of Programming Languages **3-0-3**
Formal methods for the description of programming languages. Advanced semantics models, attribute grammar, two-level grammars, fixed-point theory of computation, Program verification techniques.
Prerequisites: ICS 535 or Consent of the Instructor

6.3 Area C: Security and Net-centric Computing
Courses belonging to this area are the approved courses in the Computer Science, Security and Information Assurance, Computer Engineering and Computer Networks Masters Programs.

ICS 555 Cryptography and Data Security **3-0-3**
Mathematical principles of cryptography and data security. A detailed study of conventional and modern cryptosystems. Zero knowledge protocols. Information theory, Number theory, Group theory, Complexity Theory concepts and their applications to cryptography.
Prerequisites: Consent of Instructor

SEC 611: Cryptographic Computations **3-0-3**
Review of number theory, set algebra and finite fields. Computations in finite fields using standard and non-standard bases. High performance algorithms and architectures for cryptographic applications. Side channel analysis attack resistant computations.
Prerequisites: ICS 555

SEC 621: Advanced Network Security **3-0-3**
Intrusion detection and prevention systems. Security engineering processes. Advanced firewall considerations. Honeynets. Network forensics. Distributed denial of service attacks (Botnet, Rootkits, Zero-Day Exploits). Cyber crime and cyber war. Enterprise security policy development. Complex enterprise security infrastructure design and integration. Web and email security. P2P network security, and trust management.
Prerequisites: SEC 521

ICS 654 Advanced Topics in Computer Networking **3-0-3**
This course explores recent research trends and developments in computer networks and their applications covering state-of-the-art topics and case studies.
Prerequisites: ICS 570 or equivalent

SEC 631: Security in Operating Systems and Cloud Computing **3-0-3**
Advanced security research topics in operating systems and emerging computing paradigm such as grid and cloud computing. Secure operating system requirements, fundamentals and definitions. Security in traditional and popular operating systems such as Unix, Linux, OpenBS,D and Windows. Security kernels. Verifiable security goals, trusted processes, and information flow integrity. Secure capability systems. Security in virtualization and secure virtual machine systems. Security issues and countermeasures in cloud computing. Data security and storage in the Cloud. Security management in the cloud services: PaaS, SaaS, and IaaS. Case Studies of secure systems, design, and evaluation: SELinux and Solaris.
Prerequisites: SEC 521

6.4 Area D: Software Engineering
Courses used for this area exist in the current Software Engineering Masters program.

SWE 634 Software Reuse **(3-0-3)**
In-depth research based study of the concepts and engineering principles of software reuse with a focus on component-based reuse, domain analysis and modeling, service-oriented architectures; quality aspects of reuse, economic models of reuse; and reuse of non-code artifacts.
Prerequisite: Consent of Instructor

SWE 638 Software Maintenance & Re-Engineering **3-0-3**
Software evolution and reengineering approaches and abstraction techniques to extract specifications and design from existing code are discussed. Major maintenance activities are presented including estimating maintenance costs, managing change and predicting maintainability with software quality metrics. Organizational issues relative to product maintenance are discussed. Principles of reverse engineering techniques are also presented.
Prerequisites: Consent of Instructor

SWE 670 Formal Methods and Models in Software Engineering **3-0-3**
In-depth advanced formal mechanisms for specifying, validating, and verifying software systems. Program verification. Formal specification via algebraic specifications and abstract model specifications, including initial specification and refinement toward implementation. Integration of formal methods with existing programming languages, and the application of formal methods to requirements analysis, testing, safety analysis, and object-oriented approaches. Model-driven architectures. Formal methods using the Object Constraint Language (OCL).
Prerequisites: Consent of Instructor

SWE 671 Global Software Engineering **3-0-3**
Topics include: Essentials of global software engineering, Software engineering outsourcing (Onshore outsourcing, Nearshore Outsourcing, Offshore out-sourcing), Outsourcing models (Simple Dyadic

Outsourcing, Multi-Vendors Outsourcing, Co-Sourcing and Complex Outsourcing), Global software project management concepts, tools, and techniques, Managing virtual teams, Cross-cultural collaboration, Global project leadership, Measuring organizations readiness for global software development, Software quality in global software development (CMMI, ISO 9001:2000), Global software engineering challenges, Professional practices for global software engineering (Intellectual Property Rights, Group working, conflict and negotiations management, Presentations, writing and referencing)
Prerequisites: Consent of Instructor

6.5 Common Courses

ICS 690 Special Topic in Computer Science III **3-0-3**
Advanced topics selected from current literature that deals with theoretical foundations and advances in computer science. The specific content of an offering of the course should focus on a specific area of computer science.
Prerequisites: Consent of Instructor

ICS 691 Special Topic in Computer Science IV **3-0-3**
Advanced topics selected from current literature that deals with theoretical foundations and advances in computer science. The specific content of an offering of the course should focus on a specific area of computer science.
Prerequisites: Consent of Instructor

ICS 699 Seminar **1-0-0**
Graduate students are required to attend the seminars given by faculty members, visiting scholars, and fellow graduate students. Additionally, each student must give at least presentation on a timely research topic. Among other things, this course is designed to give the student an overview of research, research methodology, journals and professional societies. Graded on a Pass or Fail basis.
Prerequisites: Graduate standing

ICS 701 Directed Research I **3-0-3**
This course is intended to allow students to conduct research in advanced problems in their PhD area of specialization. Among other things, this course is designed to give the students an overview of research in computer science, and a familiarity with research methodology, journals and professional societies in his discipline. At the end of the course, the student must deliver a public seminar to present his work and findings. The course is graded on a Pass or Fail basis.
Prerequisites: Prior arrangement with Instructor

ICS 702 Directed Research II **3-0-3**
This course is intended to allow students to conduct research in advanced problems in their PhD area of specialization. Among other things, this course is designed to give the students an overview of research in computer science, and a familiarity with research methodology, journals and professional societies in his discipline. At the end of the course, the student must deliver a public seminar to present his work and findings. The course is graded on a Pass or Fail basis.
Prerequisites: Prior arrangement with Instructor

ICS 711 PhD Pre-Dissertation **0-0-3**
This course enables the student to submit his PhD Dissertation Proposal and defends and defends it in public. The student passes the course if the PhD Dissertation committee accepts the submitted dissertation proposal report and upon successfully passing the Dissertation proposal public defense. The course grade can be NP, NF, or IP.
Prerequisites: PhD candidacy and co-requisite: ICS 699

ICS 712 PhD Dissertation **0-0-9**

This course enables the student work on his PhD Dissertation as per submitted dissertation proposal, submit its final report and defend it in public. The student passes this course if the PhD Dissertation committee accepts the submitted final dissertation report and upon successfully passing the Dissertation public defense. The course grade can be NP, NF, or IP.

Prerequisites: ICS 711